United States Environmental Protection Agency
Air and Radiation Washington, DC 20460
EPA-430/F-00-012 Spring 2000 http://www.epa.gov/agstar

EPA AgSTAR Digest

Inside

AgSTAR 2000

As the agricultural industry enters the new century, a number of growing environmental challenges are already evident. Farmers are responding by making changes to their operations—driven in some cases by new regulations or by encroaching urbanization and local pressure, in other cases by the desire to improve productivity of the land or by the sense that protecting air and water quality is simply smart business.

Complete mix digester at Colorado Pork LLC's 5,000-sow farrowing operation.

Meeting these challenges will require farmers to develop long-term, cost-effective environmental strategies. Waste management systems—the focus of the AgSTAR program for over five years—will play a critical role in farmers' long term approaches. How animal waste is managed affects environmental performance in a number of ways, from air and water quality in surrounding communities to the productivity and profitability of the farm.

Choosing a Waste Management System. Despite the importance of waste management to a farm's overall operations, waste management systems have developed with little or no standardization or uniformity in design, construction, and operation. As might be expected with such a diversity of systems, the environmental performance of waste management systems varies widely. Farmers considering expanding or updating their current waste management systems face a myriad of options.

Although considerable research on waste management options has been undertaken, a great amount of work remains to be done to verify and pull together the research conducted to date. One of the AgSTAR program's major initiatives for 2000 is to organize and structure the existing research in a form that is accessible and useful. We are striving to provide farmers the information necessary to compare a wide array of waste management systems on environmental and cost bases. Systems we are reviewing include digesters, separators, open lagoons, pits, tanks, and aeration processes.

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AGSTAR 2000 (continued)

We are compiling information on the net capital and O&M costs of these systems, as well as on important aspects of their environmental performance. For example the table below compares the costs of single cell lagoons, covered lagoons with separate storage, and heated digesters for a 5,000-head continuous flow finishing operation in Iowa, based on the farm and cost parameters below:

- Manure is collected with pull plugs (at 3 percent total solids)
- Excavation costs are $1.50 per cubic yard
- Lagoon lining costs are $0.70 per square foot
- Concrete costs average $200 per cubic yard (placed)
- Storage period is 210 days

This comparison shows that a complete mix or covered lagoon digester in a manure treatment/storage plan can be cost-competitive when compared to a typical treatment/storage lagoon. Substituting a digester investment for a lagoon investment provides the farm owner with a free energy source, the additional benefit of odor control, and the opportunity to reduce methane and other manure-generated off-gases. Additional cost savings are achieved because of reduced lagoon volumes and lower land application costs. The stored effluent is also of uniform quality and will not be an odor source when land applied.

In This Edition. Our feature article summarizes the status of operating digesters across the country, highlighting the range of digester technologies that are currently viable options for livestock producers. This article also highlights AgSTAR's Charter Farm program, which

AgSTAR program information

All AgSTAR program information is available through the AgSTAR Hotline (**1-800-952-4782**) and website (**http://www.epa.gov/ agstar**). We are currently integrating data on environmental and cost comparisons into our fact sheets, brochure, and other informational packages—you can download these and other products from the website or call the Hotline to request hard copies. The website also has direct links to related industry, vendor, and utility sites, and the Hotline can provide information about the Digester Farm Days sponsored throughout the country by AgSTAR, which offer farmers an opportunity to view commercial-scale biogas systems firsthand.

Table 1. Estimated Costs of Waste System Options for 5,000 Finish Hogs[1]

	Estimated treatment cost	Estimated storage cost	Estimated total cost	Net benefit as propane $/year*	Net cost per pig capacity
Treatment option, HDPE-lined					
Single cell lagoon	$292,132	included	$292,132	0	$58.43
Two-cell lagoon, one cell covered	$236,034	$ 82,378	$318,412	$20,454	$59.59
Complete mix digester	$184,740	$ 82,378	$267,118	$12,893	$50.85
Treatment option, no liner					
Single cell lagoon	$166,289	included	$166,289	0	$33.26
One cell covered	$193,387	$41,784	$235,171	$20,454	$42.94
Complete mix digester	$184,740	$41,784	$226,524	$12,893	$42.73

*Propane @ $0.50/gallon

[1] Adapted from Keeping The Neighbors Happy—Reducing Odor While Making Biogas. Mark A. Moser, Richard P. Mattocks, Dr. Stacy Gettier, and Kurt F. Roos. Presented at: Animal Production Systems and the Environment, Ames, IA, July 19–22, 1998.

completed its twelfth and final demonstration system last fall. The Technical Corner contains the latest information on lagoon cover costs and approaches for odor control and energy production. Finally, the Showcase Corner provides a snapshot review of Apex Pork's innovative covered heated mixed earthen digester for odor abatement and manure treatment—a useful case study as issues related to odor continue to emerge. The Haubenschild Dairy article illustrates the environmental and business opportunities a digester provides for the farm, the community, and rural electric systems.

Julian Barham and his bank-to-bank covered lagoon—1999 winner of the National Pork Producers Council Environmental Stewardship Award.

A Preview of Things to Come. Thanks to the completion of these systems, we are excited to announce that the number and types of digester Farm Days will be expanded from last year. The Farm Days provide firsthand exposure to a variety of biogas systems and gas uses as explained by their operators. Farm Days also provide a great opportunity to network within the agricultural and energy industries. The first Farm Day of the year will be held at Haubenschild Farms in Princeton, Minnesota and will showcase the recently installed heated plug flow digester at the Haubenschild's 500-cow freestall dairy. A second Farm Day is scheduled in Lamar, Colorado. It will showcase Colorado Pork, LLC's complete mix digester and energy recovery system.

And a Look Back. It seems fitting to end our overview of the AgSTAR program in the year 2000 by mentioning the impressive accomplishments of several of our Partners in 1999. We are delighted to announce that Julian and Elaine Barham won the 1999 Environmental Stewardship Award from the National Pork Producers Council and that Mr. Barham was featured in the September issue of *National Hog Farmer.* The Barhams use a covered anaerobic lagoon for waste management, electricity generation, and heat production. Also featured in the August, 1999 issue of *National Hog Farmer* was Glenn Saline of Apex Pork, who installed an innovative heated, covered anaerobic lagoon. (See the Showcase Corner for more information on the Apex Pork digester.) We congratulate Mr. Saline and the Barhams, and all partners whose innovation improves our capacity to manage waste soundly and economically, and we look forward to working with you in 2000 and beyond.

How animal waste is managed affects environmental performance in a number of ways, from air and water quality in surrounding communities to the productivity and profitability of the farm.

CURRENT STATUS OF FARM-SCALE DIGESTERS

In preparing this issue of the AgSTAR Digest, we followed up with digester owners to provide a brief report on the status of farm-scale digesters currently operating at commercial livestock farms in the U.S.

Currently, 31 digester systems are in operation at commercial livestock farms. Of these, 15 are at swine farms, 14 are at dairy farms, and 2 are at caged layer farms.

Eighteen systems were installed during the 1990's—more than doubling the number of successful systems installed during prior years. (See Figure 1 below.) Twelve of the 31 digesters are at participating AgSTAR Charter farms, and many of these were completed in coordination with emerging state agricultural energy programs in Iowa, Minnesota, and New York.

In 23 of the 31 systems, the captured biogas is used to generate electrical power and heat. In 1999, these systems in total produced roughly 1 million MWh of power. The remaining 8 systems flare the captured gas for odor control.

The 31 operating digesters prevented over 4,800 metric tons of methane from entering the atmosphere (approximately 27,500 metric tons on a carbon-equivalent basis).

The table on pages 5 and 6 provides detailed information about each of the operating digester systems. The table is organized by digester type (i.e., covered anaerobic lagoon, complete mix, and plug flow configurations). The map on page 7 illustrates the location of each system. Swine and dairy currently account for the majority of methane emissions from livestock management.[1]

[1] *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1997.* U.S. EPA, EPA 236-R-99-003, April 1999.

Figure 1: Operating Farm Scale Digesters

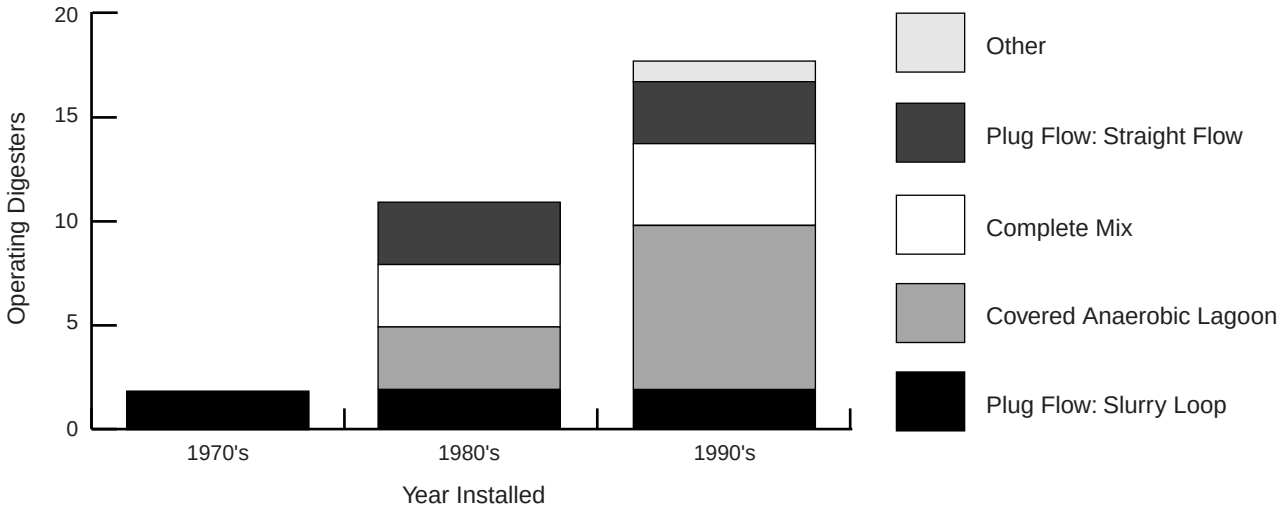

Table 2: U.S. Operating Digesters, March 2000 (Bold text indicates AgSTAR Charter Farms)

Location	Year built	Animal type and population	Manure handling	Installed cost	Biogas end-use	CH4 reduction Mt CE/year*
COVERED LAGOON						
CA	1982	Swine; 1,650 sows farrow-to-finish	Flush	$220,000	Electricity and hot air	2,316
CA	1984	Swine; 900 sows farrow-to-finish	Flush	$120,000	Electricity and hot air	1,263
CA	1986	Swine; 550 sows farrow-to-finish	Flush and gravity drain	$75,000	Electricity and hot air	772
VA	**1993**	**Swine; 600 sows farrow-to-feeder**	**Flush and pull plug**	**$85,000**	**Electricity**	**397**
NC	**1997**	**Swine; 4,000 sows farrow-to-wean**	**Pull plug**	**$290,000**	**Electricity and hot water**	**1,158**
IA	**1998**	**Swine; 3,000 nursery pits**	**Pull plug**	**$15,000**	**Flare**	**Never metered**
CA	**1998**	**Dairy; 200 cows**	**Flush**	**$150,000**	**Flare**	**149**
MS	**1998**	**Swine; 120 pigs**	**Hose wash**	**$19,000**	**Flare**	**17**
NC	1999	Swine; 400 sows farrow-nursery	Flush	$22,150	Flare	146
WI	1999	Dairy; 1,100 milkers	Scrape	$37,300	Flare	Never metered
WI	1999	Dairy; 1,300 milkers	Scrape	$122,000	Flare	Never metered

* Greenhouse gas emissions in the U.S. are most commonly expressed as metric tons of carbon equivalents (Mt CE/year). This measure is used to compare the emissions of different greenhouse gases based on their global warming potential.

Location	Year built	Animal type and population	Manure handling	Installed cost	Biogas end-use	CH4 reduction Mt CE/year
COMPLETE MIX						
NC	1983	Caged layers; 70,000	Scrape	$225,000	Electricity	1,129
NY	1985	Dairy; 270 milkers	Scrape	$500,000*	Electricity and hot water	672
*includes other costs associated with the farm's manure management system (e.g., storage tanks, alley scrapers)						
PA	**1985**	**Swine; 1,000 sows farrow-to-finish**	**Scrape**	**$325,000**	**Electricity and hot water**	**1,210**
CT	1997	Dairy; 600 milkers	Scrape	$450,000	Electricity	1,210
IL	**1998**	**Swine; 8,600 finishing hogs**	**Pull plug**	**$152,300**	**Hot water and flare**	**1,191**
IA	**1999**	**Swine; 5,000 sows farrow-to-wean**	**Pull plug**	**$546,000**	**Electricity**	**959**
CO	**1999**	**Swine; 5,000 sows farrow-to-wean**	**Pull plug**	**$368,000**	**Electricity**	**1,013**
PLUG FLOW-STRAIGHT FLOW CONFIGURATION						
MI	1981	Dairy; 720 milkers	Scrape	$150,000	Electricity	1,169
VT	1982	Dairy; 340 milkers	Scrape	$185,000	Electricity and hot water	1,008
CA	**1982**	**Dairy; 400 milkers**	**Scrape**	**$200,000**	**Electricity and hot water**	**806**
OR	**1997**	**Dairy; 1,000 milkers**	**Scrape**	**$287,300**	**Electricity**	**1,129**
NY	**1998**	**Dairy; 1,000 milkers**	**Scrape**	**$295,700**	**Electricity**	**1,129**
MN	**1999**	**Dairy; 1,000 milkers**	**Scrape**	**$295,853**	**Electricity**	**992**
PLUG FLOW-SLURRY LOOP CONFIGURATION						
IA	1972	Swine; 150 sows	Flush	$20,000	Flare	Never measured
PA	1979	Dairy; 2,000 milkers	Scrape	$260,000	Electricity and hot water	5,107
PA	1983	Caged layer; 70,000	Scrape	$140,000	Electricity and hot water	753
PA	1983	Dairy; 250 milkers	Scrape	$120,000	Electricity and hot water	538
CT	1997	Dairy; 200 milkers	Scrape	$149,000	Hot water and flare	242
MD	1994	Dairy; 450 total head	Scrape	$500,000*	Flare	349
*includes other costs associated with the farm's manure management system (e.g., storage tanks, alley scrapers)						
OTHER DIGESTER TYPES						
IA	1999	Swine; 2,800 finishing hogs	Scrape	$244,675	Hot water and flare	827

Figure 2: Operating farm-scale digester systems

ENVIRONMENTAL CORNER

Anaerobic Lagoon Covers for Energy Production and Odor Control

In the United States, about 40 livestock lagoons have been covered to collect and/or control methane and odorous off-gases generated from manure. Many of these covers are on single-cell lagoons, which do not take advantage of the environmental and financial benefits of separating the treatment and storage functions. The majority of these covered lagoons also vent unburned gases to the atmosphere. Eight livestock facilities, however, have designed lagoon covers that collect gases for combustion in odor control flares, boilers, and engine generators. The cost of covers used in these applications ranges from $0.37 to $1.75 per square foot installed.

Separating the treatment and storage functions. Where covered anaerobic lagoons are used for odor control and energy production, the system typically consists of two separate lagoons operating in series[1]. The first lagoon is a covered, fixed-volume treatment lagoon designed to biologically stabilize manure influent. Here, offgases are collected and combusted. The second, uncovered lagoon is used to store treated effluent from the first lagoon during non-cropping periods. Separating the storage and treatment functions improves manure decomposition and requires significantly less total lagoon volume. In many cases, the savings in lagoon excavation costs achieved by separating the treatment and storage functions can pay for most of the lagoon cover costs.

Quality control considerations. To achieve odor control and/or energy production, the lagoon cover must continuously collect lagoon-generated biogas at a dedicated gas take-off point for transmission to a flare, boiler, or generator. The cover must be capable of collecting the biogas even during periods of precipitation.

If the end-use for the collected gas is energy production, the quality control in cover fabrication, assembly, and installation must be high enough to limit air intrusion. If the end-use is solely odor control (i.e., if the collected gas is flared), quality control can be eased somewhat because air infiltration is less of a concern.

Before constructing a lagoon cover, the following critical variables must be considered:

Materials: Cover materials need to withstand sun, wind, extremes in temperature, and other climate variables. Material resistance to capillary action (i.e., wicking) should also be considered.

Fabrication: Quality, gas-tight seams are a key requirement for all lagoon covers that collect gas for combustion.

Design: The cover design must factor in gas and rainfall management as well as stresses caused by extremes in weather. Poor design can impede or cut off gas flow, cause air to intrude, or—in extreme cases—cause complete cover failure.

Basic lagoon cover designs. There are two basic types of lagoon cover designs: bank-to-bank and modular. Both designs can effectively collect biogas and reduce odor.

Bank-to-Bank covers completely span the lagoon surface with a fabricated floating cover. To secure the cover to the lagoon bank, the cover's edges are buried in perimeter trenches. Burying the cover edges creates a completely anaerobic environment, ensures the capture of all off-gases produced, and excludes rainfall from the lagoon. For bank-to-bank covers to function effectively, incident rainfall removal mechanisms must be included. Rainwater management must also be considered in the cover design to ensure against longer-term cover performance problems.

AgSTAR Farm Day demonstration of seaming process for lagoon covers

Modular covers use smaller cover sections, or modules, as opposed to the single large cover used in bank-to-bank designs. The owner or supplier can build the modules offsite and then assemble the cover on site. The lagoon can be covered in stages, thereby reducing the need for a large initial capital outlay. Modular lagoon covers typically cover 50 to 90 percent of a lagoon's surface and can be secured either with bank trenching or tether ropes. Modular covers do not catch all gas, nor do they exclude all rainfall. Flotation and rainfall management must be included in the design. When sizing a treatment lagoon for a modular cover, rainfall addition must be accounted for if rainfall is allowed to enter the treatment lagoon.

For more information on covered lagoons and other environmentally smart waste management systems, or to review a copy of the Industry Directory for On-Farm Biogas Recovery Systems, visit the AgSTAR website or call the AgSTAR hotline.

[1] As prescribed under NRCS Interim Design Standard No. 360

SHOWCASE CORNER

Haubenschild Dairy

In September 1999, Dennis Haubenschild and sons Tom and Bryan, owners and operators of Haubenschild Farms in Princeton, Minnesota, completed the installation of a heated plug flow digester at their 500-cow freestall dairy.

The digester, which measures 130 feet long, 30 feet wide, and 14 feet deep, is sized to treat manure from up to 1000 milk cows. Manure from the freestall barns is scraped twice a day into a collection tank. From the tank, the manure flows into a mix pit before it is pumped into the digester.

"Its great! After 20 years of thinking about it, the system is working, meeting and exceeding my expectations, particularly my environmental expectations."

—Dennis Haubenschild

The digester is covered by an impermeable coated plastic material and is equipped with a network of water-heated pipes that maintain an appropriate digester temperature of 100 degrees Fahrenheit. Under the anaerobic conditions within the digester, the manure is broken down to produce biogas and a nutrient-rich effluent. The effluent flows via gravity into a nearly odor-free storage basin and is then land-applied. The methane-rich biogas fuels a Caterpillar 3406 engine attached to a 150 kW generator. The Haubenschilds sell all the excess electricity produced to their local electric cooperative, East Central Energy. Heat, recovered as hot water from the engine and exhaust, is stored in an insulated 3,800-gallon tank and is used to maintain the digester's temperature and to heat the floor of the milking parlor.

Haubenschild Farms heated plug-flow digester

In its first seven months, the system operated over 96 percent of the time, producing 320,000 kWh of power from 8 million cubic feet of biogas. The system produces over 33 percent more electricity than is used on the farm. Propane purchase have been all but eliminated, and areas are now heated which were not winterized before.

By Fall 2000, the Haubenschilds will complete construction on a second barn that will house an additional 500 cows. Barn floors will be heated with hot water from the digester system.

A cost breakdown for this digester is shown in Table 3 below.

Table 3: Haubenschild Farms Heated Plug Flow Digester Costs

	Cost
Collection Tank	$29,505
Cogeneration Building	$155,503
Digester	$111,313
TOTAL COST	**$295,853**
Savings after first 7 months of operation	$24,200

The methane recovery system at Haubenschild Farms has produced revenues from sale of electricity and reduced farm expenditures by virtually eliminating propane purchases, while contributing to the farm's environmentally sound manure management strategy. The value of energy production over the 7-month period is about $23,000 in electricity and $1,200 in propane.

"We're very pleased to assist the Haubenschilds in the development of this exciting new renewable energy project and the results are particularly noteworthy," said Henry Fischer, East Central Energy's (ECE's) Manager of Business and Community Development. "This project exemplifies ECE's mission, which is to enhance the quality of life and provide premier service to our customers," Fischer added.

Under a power purchase agreement, ECE purchases all excess energy from the Haubenschild farm under the cooperative's general service three phase rate and ECE resells the energy to other customers who participate in the cooperative's Wellspring renewable energy program.

The engine room at Haubenschild Farms

"The Haubenschild Farm project is an excellent example of how agriculture, utilities, environmental organizations, community groups, and others can effectively pool their resources to develop renewable energy, promote sustainable agriculture, and ensure environmental stewardship," Fischer pointed out.

SHOWCASE CORNER

Apex Pork

It has smelled a lot better in Rio, Illinois since 1998. That year, Glenn Saline of Apex Pork installed a methane digester next to the single cell lagoon at his 8,600-head finishing site. The operation of the digester has significantly reduced odors—and neighbors' complaints.

Manure from nine grow-finish buildings used to flow into a variable-depth single-cell lagoon with a surface area of 6 acres and a depth of 13 feet. This configuration led to seasonal odor episodes from the lagoon. To control odor, the manure now flows into a covered heated

1999 AgSTAR Farm Day at Apex Pork

mixed earthen digester that measures 120 x 160 x 17 feet. The digester can hold roughly 20 days' worth of manure before the treated manure enters the original lagoon now used for storage. Mixing and heating allow for year-round digestion. The alternative would have been an ambient-temperature lagoon 20 times the size of the current digester.

"I think we've dramatically reduced those odors, and we're expecting that to continue to improve."

— Glen Saline

PHOTO NATIONAL HOG FARMER, 1999

Floating gas collection cover at Apex Pork

A submersible propeller mixer, located near the bottom of the lagoon, mixes and suspends manure solids daily. Bacteria in the digester convert soluble and suspended organic compounds into methane, carbon dioxide, and water. The methane and carbon dioxide bubble to the surface of the digester, where the methane is collected under the digester cover and piped to a small boiler. Hot water is pumped back into the digester to maintain slurry temperature (ideally, 85-105 degrees F). This heating system allows the bacteria to work effectively in the winter. Digested manure flows into the storage basin—now nearly odor-free—and is held until crop, soil, and weather conditions are appropriate for land application.

Table 4: Apex Pork Complete Mix Digester Costs

	Cost
Manure transfer pipe	$1,400
Excavation	$24,000
Digester cover	$39,700
Digester mechanical	$21,000
Gas pump, meter, piping	$6,200
Engine-generator	$0
Boiler	$17,600
Hot water use equipment	$0
Engine-generator building	$5,700
Farm labor, electrical	$5,000
SUBTOTAL	**$120,600**
Engineering and permits	$19,000
Startup	$8,000
TOTAL COST	**$147,600**

The digester cost approximately $150,000 to build. (See Table 4 at left.) Annual operating costs are about $500 for electricity for pumps, while maintenance costs to date have been less than $500 per year. Estimated long-term operating and maintenance costs are about $2,000 per year.

According to Saline, the benefits are worth the cost. These include improved effluent for land application and—most importantly—significantly reduced odors. "I think we've dramatically reduced those odors, and we're expecting that to continue to improve," says Saline. "We feel like we have tried hard and we feel good about what we have done."

For more information about methane recovery technologies or the AgSTAR Program, contact an AgSTAR representative at:

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